COMPARATIVE TESTS
ON
SMALL STEAM PUMPS
BY
R. L. LEWIS and J. E. MONAHAN

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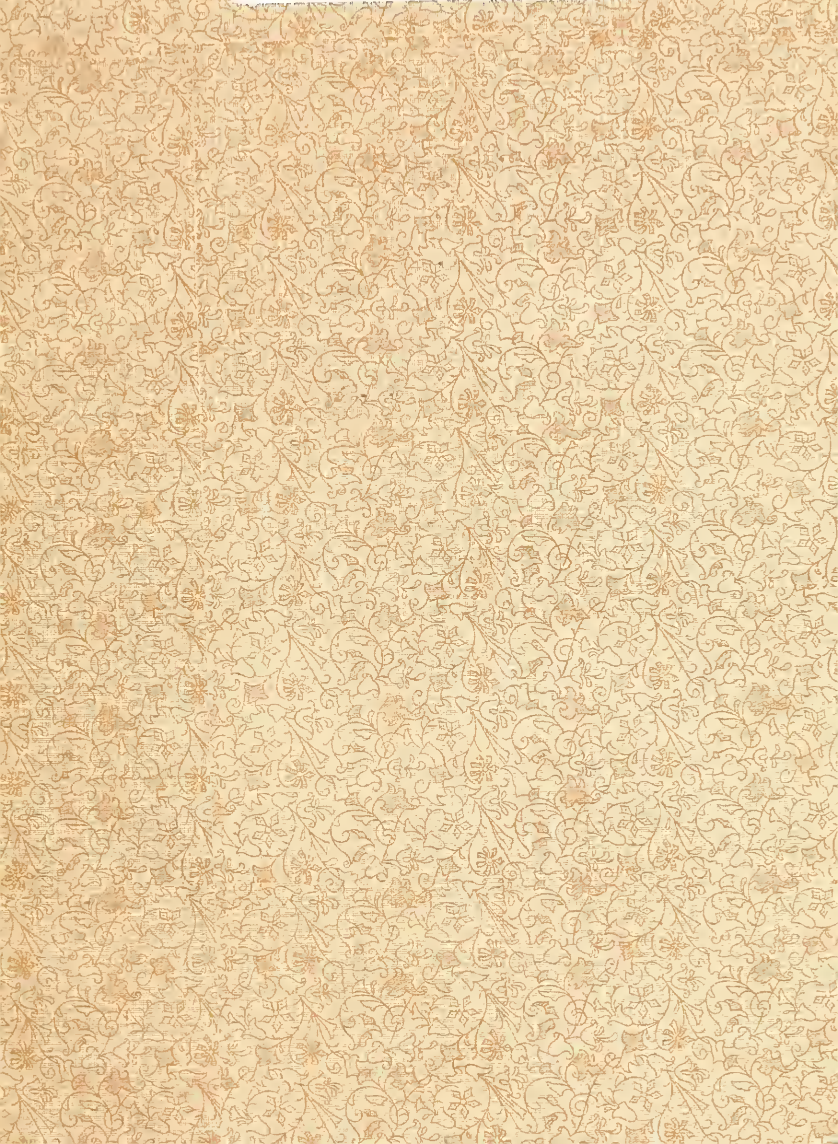

COMPARATIVE TESTS
ON
SMALL STEAM PUMPS

A THESIS

PRESENTED BY

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ON
SMALL STEAM PUMPS.

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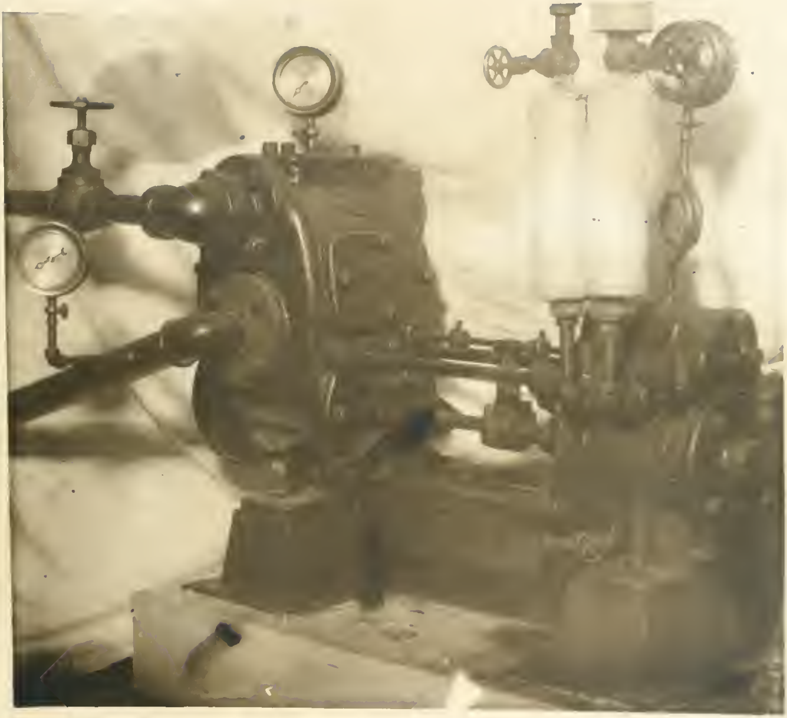
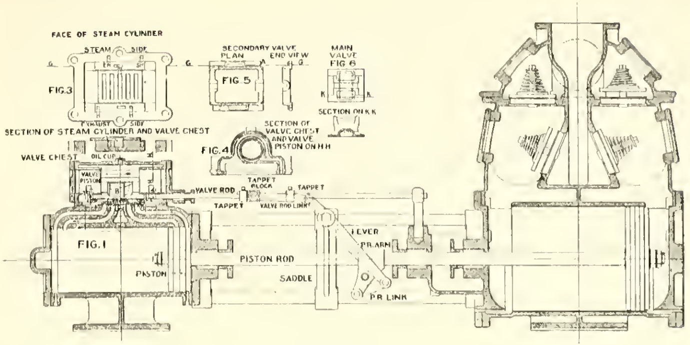
INTRODUCTION.

In view of the fact that so little is known concerning the performance of small direct acting steam pumps, this subject was chosen as one giving promise of considerable interest.

Two pumps were selected of approximately the same size, but of different makes. One was a Deane 3-1/2 x 5 x 5 vacuum pump which had seen about sixteen years service. The other was a Burnham 4 x 4 x 5 vacuum pump which was practically new.

Both pumps were run under as nearly similar conditions as possible, taking in each case sufficient data for calculating the duty, capacity and water rate of each.





THE DEANE
OF HOLYOKE
VACUUM PUMP.

TESTS ON THE DEANE PUMP.

The Deane pump was arranged for the tests as shown in the accompanying illustration. As a matter of convenience the steam gauge was connected directly to the valve chest, thus being under the throttle so that a constant supply pressure could be maintained. In order to determine the amount of steam used, the exhaust was passed through a Wheeler surface condenser into a weighing tank mounted on scales. The water supply was obtained from a sump just below the floor level of the pump. The discharge gauge was directly connected to the outlet of the water cylinder without the use of an air chamber, as sufficient constancy in the reading could be maintained by throttling the gauge. On account of the conditions in the piping, it was found convenient to pump the water through the condenser during its passage to the weighing tanks, thereby having it serve the purpose of cooling water. This accordingly raised its temperature so that it was necessary to place a thermometer in the pipe line between the pump and the weighing tanks. In this way

we were able more accurately to determine the actual volume of water pumped.

After weighing the water it was allowed to re-enter the sump.

A series of thirty minute runs were made with varying speed, in each case determining the amount of condensed steam. Readings were also made at ten minute intervals of the steam pressure, the suction and discharge heads, and the number of strokes per minute. As the steam pressure was kept constant at 80# pressure for each run, the other conditions remained constant.

The speed was regulated by means of the discharge valve, which was set at the beginning of each run and remained unchanged throughout that run.

On account of the small size of the pump, it was deemed unadvisable to equip it with indicators, so that we did not have the usual accurate means of measuring the stroke. The method used was to hold a pencil against a certain point on the piston rod, and when the rod moved back and forth, this pencil drew a line on a white surface which was very ap-

proximately the length of the stroke.

Calculations were made of the capacity, the horse power delivered by the pump, the slip, the water rate, and the duty. Since the method of these calculations is similar to that ordinarily used, it is not given here.

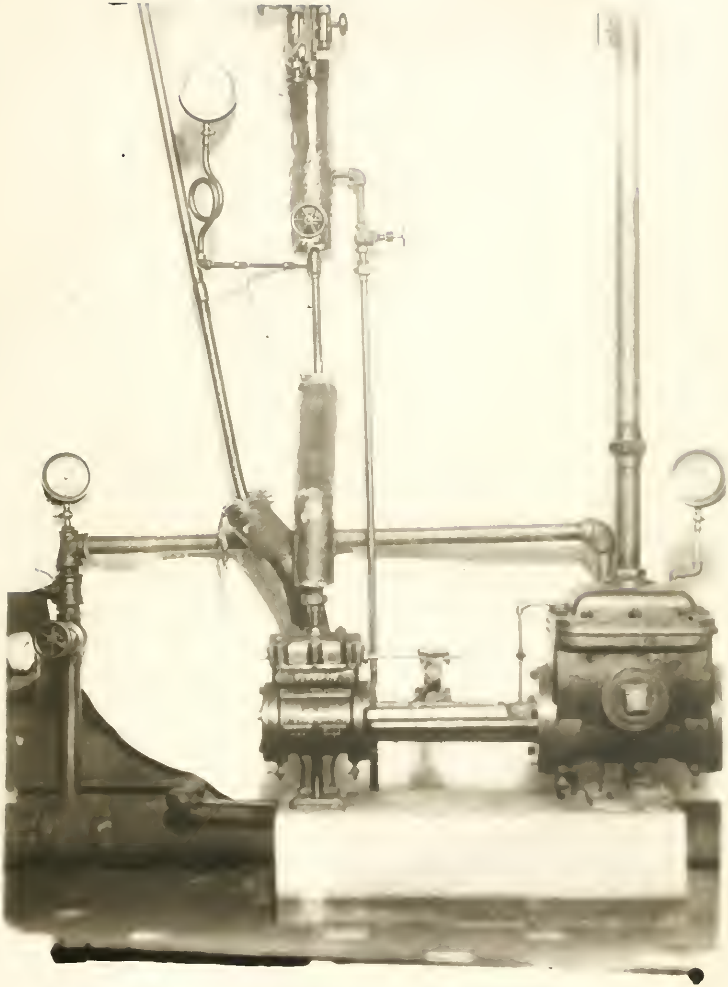
RUNNING LOG Of TEST on DEANE PUMP.

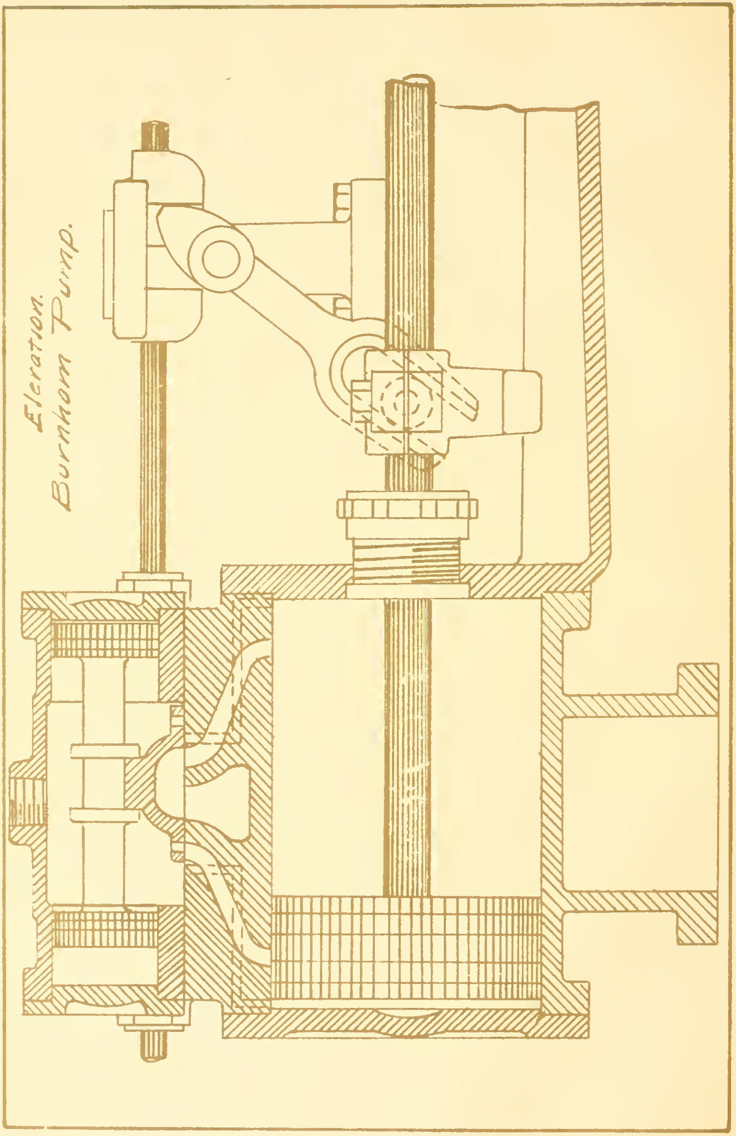
Giving Average Values.

RUN	Stm Pr #pr sq"	Back Press "of vac.	Cond Stm #pr hr	Suction " of Hg	Dis Pr #pr sq"	Strokes per min	Wtr Pmpd #pr hr	Temp Disc. °F
1	80	3.7	88	3.0	20.8	19	3132	132
2	80	3.2	100	3.0	20	36	5742	130
3	80	3.0	108	3.0	20	52	9216	125
4	80	2.3	108	3.0	20	57	10063	109
5	80	2.0	104	2.8	20	75	13158	111
6	80	2.4	110	3.0	19.5	81	14326	112
7	80	2.5	119	3.5	19.5	98	17426	107

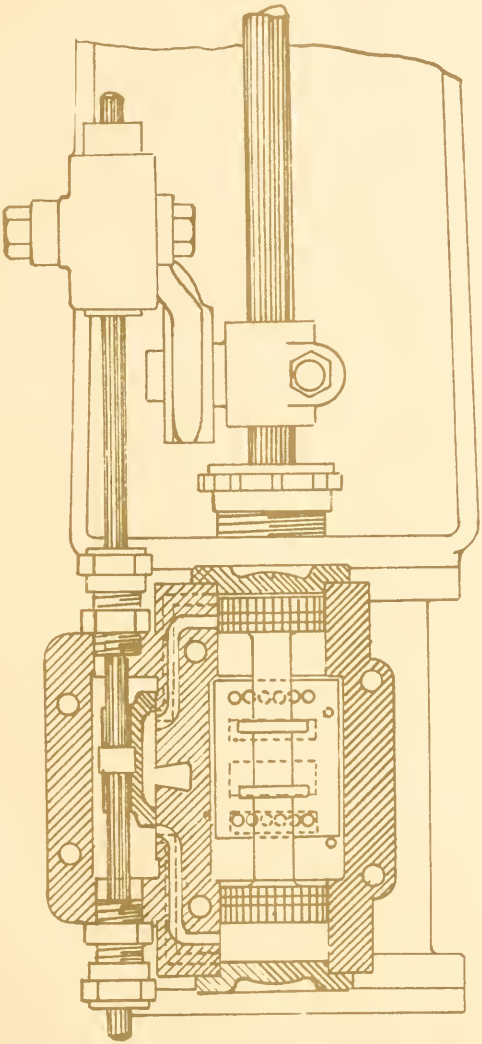
PERFORMANCE OF DEANE PUMP.

Run Number	1	2	3	4	5	6	7
Strokes per Minute	19	36	52	57	75	81	98
Water Pumped per hr - lbs.	3132	5742	9216	10068	13158	14326	17426
Cap. Gals. per minute	6.25	11,45	18.4	20.1	26.3	28.7	34.9
Total Lift of Pump - feet	51.6	49.7	49.7	49.7	49.7	49.7	49.7
Work Done pr hr - ft lbs	161500	285000	458000	499600	654000	713000	866000
Horse Power Delivered	.082	.144	.232	.252	.330	.360	.438
Slip of Pump - Per Cent	0	2.6	4.4	3.5	118	1.7	1.5
Water Rate-lbs pr HP pr hr.	1070	694	466	929	316	306	272
Heat Supplied pr Hr - B.t.u.	99800	113600	122700	122700	118000	125000	135000
Duty-ft lbs pr million B tu	1618000	2510000	3740000	4070000	5540000	5710000	6410000





Elevation.
Burnhom Pump.



Plan.
Burnham Pump.

TESTS ON THE BURNHAM PUMP.

The tests on the Burnham pump were made under conditions which were as similar as possible to those which prevailed when the Deane pump was being used. The system of piping used is shown in the illustration.

On account of the small size of the pump, it was found convenient to condense the steam by passing it into a tank of water mounted on scales. The increase of weight in a given time gave the amount of steam used during that period. In the piping to this tank, a suitable outlet for the steam was made by attaching a three-foot length of 2" pipe to the end of the regular 3/4" exhaust pipe. To make the condensing effect still more gradual about 20-1/4" holes were drilled in the larger pipe.

It was found most convenient to take the water direct from the city mains, from which it was pumped directly into large weighing tanks mounted on scales. From these tanks it was released into the sewer.

The steam gauge was attached on the supply pipe directly below the throttle, and a constant pressure of 80# was maintained, as in the previous tests.

As the intake valves were designed for suction, it was necessary to throttle the supply to 5# in order to insure their closing. The discharge gauge was attached directly to the outlet chamber of the water cylinder as in the previous case.

The method of procedure and calculations for the tests made on this pump do not need to be repeated as they were similar to those used on the Deane pump.

RUNNING LOG - BURNHAM PUMP.

Run	St. Pres per sq in	Back Pres " Hg	Cond Stm #per hr	Suction #pr sq"	Disch Pr. #pr sq "	Strokes pr min	Water pumped pr hr.
1	80	30"	50	5	73.5	14	1094
2	80	30"	58	5	73.0	23.5	215
3	80	30"	70	5	70	42.5	425
4	80	30"	72	5	70	60.0	62
5	80	30"	76	5	68	79.0	83
6	80	30"	89	5	68	92.0	95
7	80	30"	116	5	65	121.0	153
8	80	30"	122	5	63	142.0	173
9	80	30"	128	5	59.5	167.0	230

PERFORMANCE of BURNHAM PUMP.

RUN	1	2	3	4	5	6	7
Strokes per minute	14	23.5	42.5	60	79	92	121
Water pumped per hr - lbs.	1094	2158	4254	6288	8304	9590	15396
Cap. gals per minute	2.13	4.32	8.51	12.57	16.61	19.18	30.79
Total Lift of Pump - ft.	158.0	156.5	150.8	150.8	145	145	138.5
Work done pr hr - ft. lbs.	173100	338000	640000	950000	1205000	1390000	213000
Horse power delivered	.0875	.148	.310	.475	.605	.703	1.07
Slip of Pump - Per Cent	12.4	27.2	16.6	2.4	2.8	14.0	6.4
Water Rate - lbs pr h.p. pr hr.	572	392	226	151.5	126.0	126	108
Heat supplied pr Hr B.t.u.	56800	67000	79600	81800	86200	101000	131560
Duty - ft lbs pr million Btu	3500000	5050000	8050000	11600000	14000000	13800000	162000

PERFORMANCE of BURNHAM PUMP.

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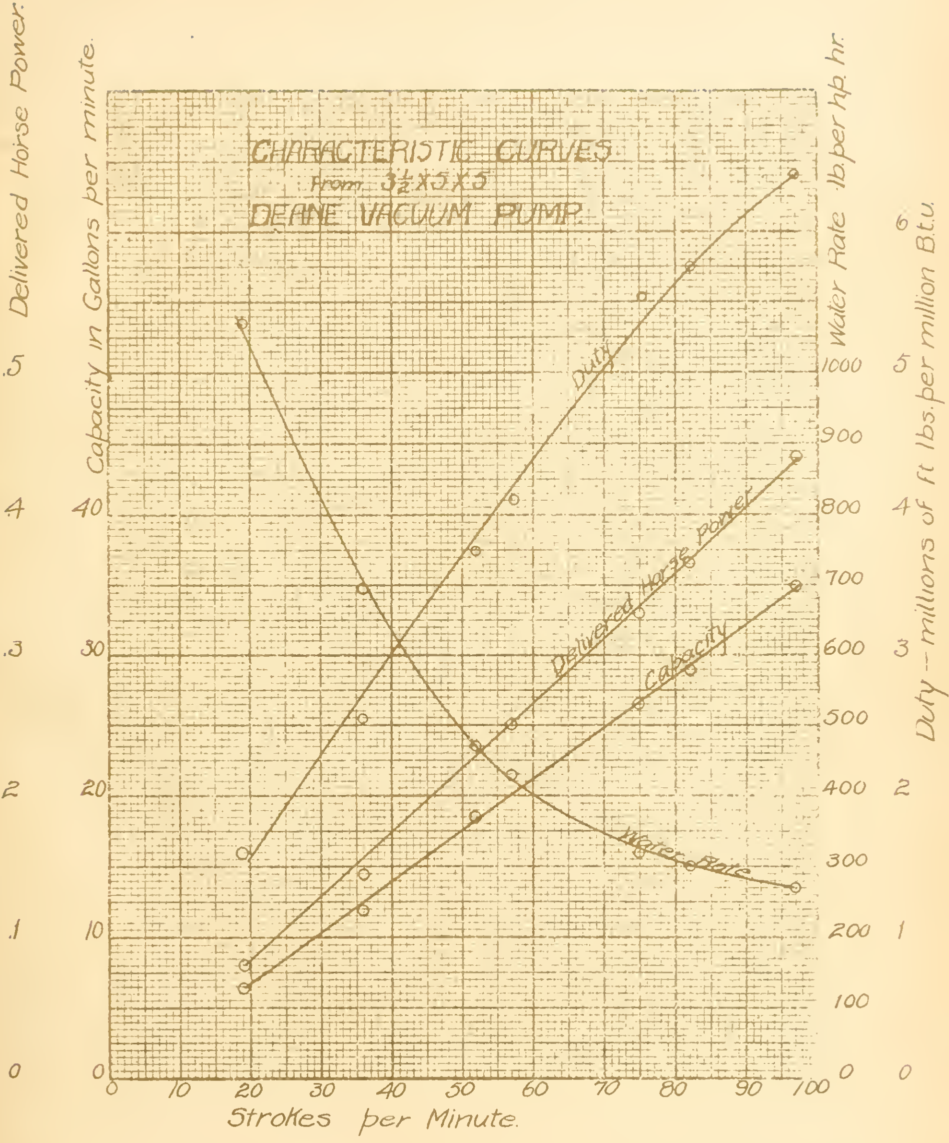
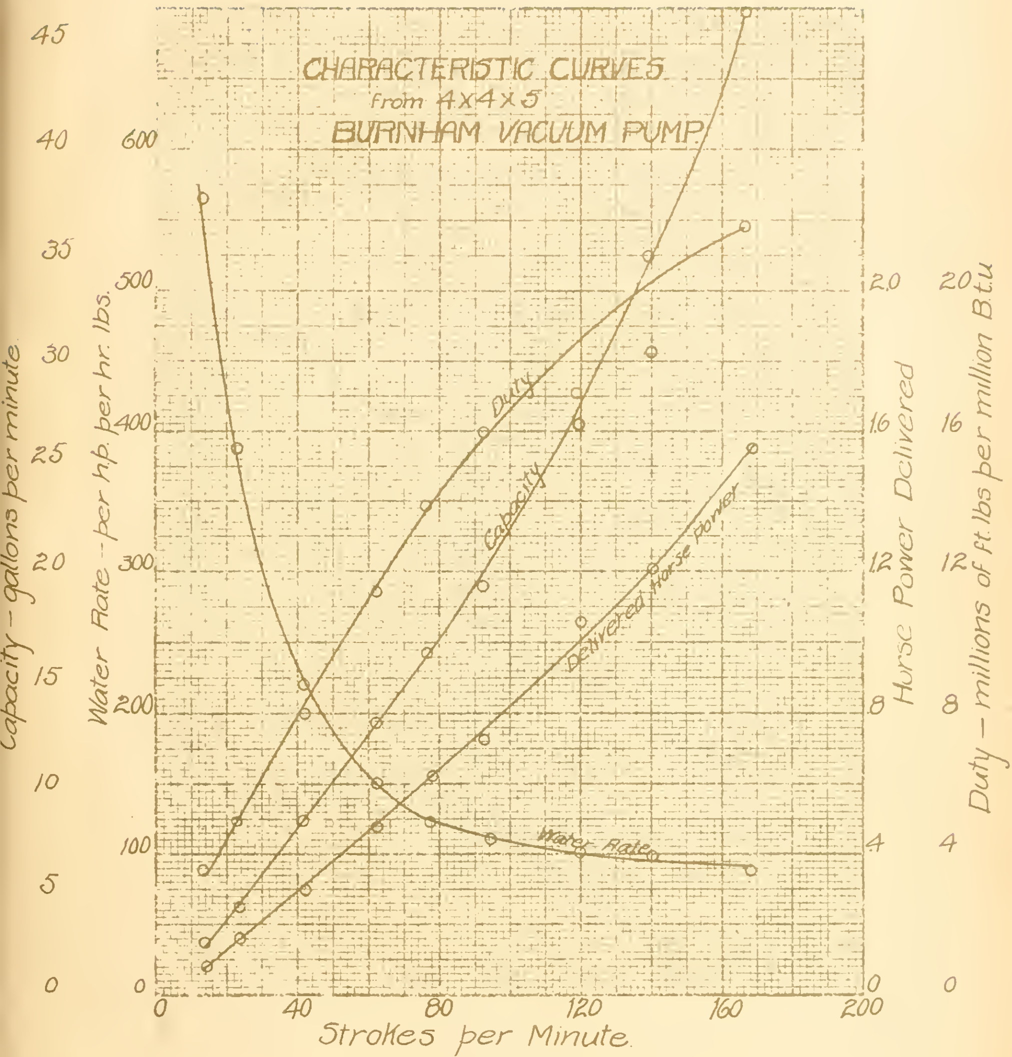
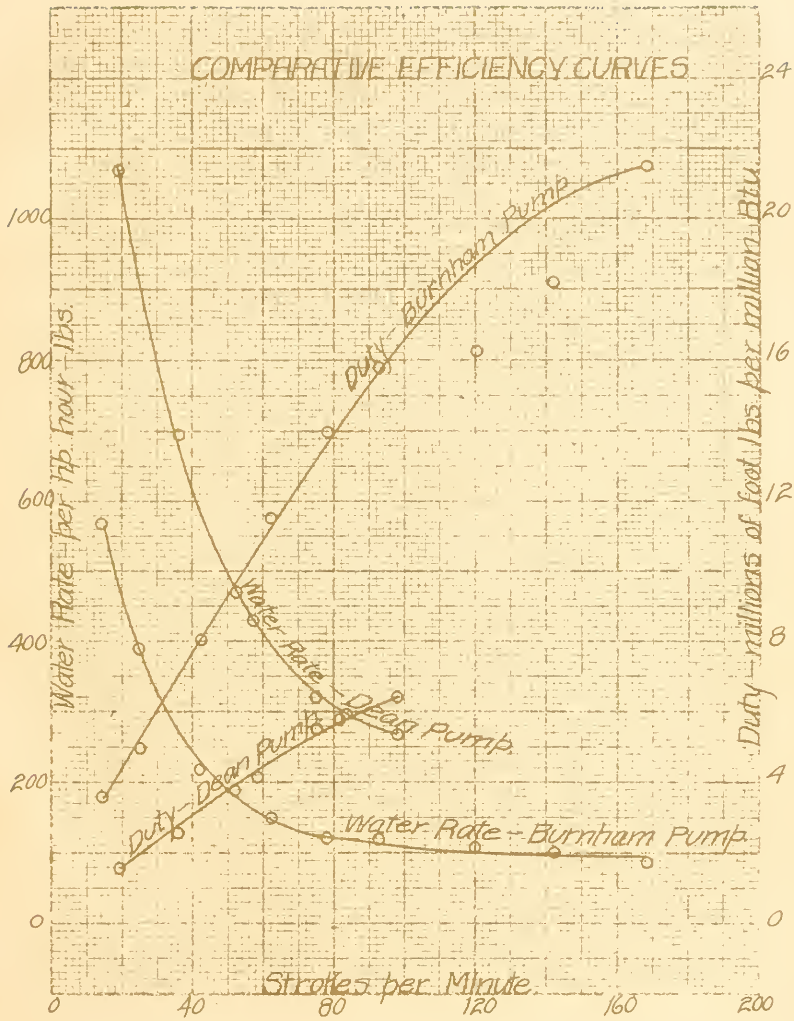
Duty - ft lbs pr million Btu	3500000	5050000	8050000	11600000	14000000	13800000	16200

PERFORMANCE of BURNHAM PUMP.

RUN	1	2	3	4	5	6	7	8	9
Strokes per minute	14	23.5	42.5	60	79	92	121	142	167
Water pumped per hr - lbs.	1094	2158	4254	6288	8304	9590	15396	17384	23076
Cap. gals per minute	2.13	4.32	8.51	12.57	16.61	19.18	30.79	34.77	46.15
Total Lift of Pump - ft.	158.0	156.5	150.8	150.8	145	145	138.5	134	126
Work done pr hr - ft. lbs.	173100	338000	640000	950000	1205000	1390000	2130000	232400	3136000
Horse power delivered	.0875	.148	.310	.475	.605	.703	1.070	1.175	1.57
Slip of Pump - Per Cent	12.4	27.2	16.6	2.4	2.8	14.0	6.4	8.8	2.6
Water Rate - lbs pr h.p. pr hr.	572	392	226	151.5	126.0	126	103	104	81.
Heat supplied pr Hr B.t.u.	56800	67000	79600	81800	86200	101000	131560	138400	145200
Duty - ft lbs pr million Btu	3500000	5050000	8050000	11600000	14000000	13800000	16200000	16800000	21600000


CHARACTERISTIC CURVES
From 3½x5x5
DEANE VACUUM PUMP
Delivered Horse Power.
Capacity in Gallons per minute.
Water Rate lb. per hp. hr.
Duty -- millions of ft lbs. per million B.t.u.
Duty
Delivered Horse power
Capacity
Water Rate
0
.1
.2
.3
.4
.5
0
10
20
30
40
0
100
200
300
400
500
600
700
800
900
1000
0
1
2
3
4
5
6
0
10
20
30
40
50
60
70
80
90
100
Strokes per Minute.


CHARACTERISTIC CURVES
from 4x4x5
BURNHAM VACUUM PUMP
Capacity - gallons per minute
0
5
10
15
20
25
30
35
40
45
Water Rate - per h.p. per hr. lbs.
0
100
200
300
400
500
600
Horse Power Delivered
0
.4
.8
1.2
1.6
2.0
Duty - millions of ft. lbs per million B.t.u.
0
4
8
12
16
20
Duty
Capacity
Delivered Horse Power
Water Rate
0
40
80
120
160
200
Strokes per Minute


COMPARATIVE EFFICIENCY CURVES
Water Rate per hp. hour lbs.
Duty - millions of foot lbs. per million Btu.
Strokes per Minute
Duty - Burnham Pump
Water Rate - Dean Pump
Duty - Dean Pump
Water Rate - Burnham Pump
0
200
400
600
800
1000
0
4
8
12
16
20
24
0
40
80
120
160
200

CONCLUSIONS.

One interesting result brought out by these tests was that throttling the discharge valve had merely the effect of decreasing the speed of the pump without materially affecting the discharge pressure, this, of course, being with a constant steam pressure. An explanation for this is that the constant pressure on the steam piston is just balanced by the pressure on the water piston, so that when the discharge valve is opened the piston must travel faster in order to maintain this balance.

Regarding the leakage or slip, the values obtained for the Deane were reasonably low. But in the case of the Burnham, they were rather high. The good results obtained by the Deane can be explained by the fact that the piston had been repacked just previous to the tests. In the Burnham, the inlet valves had to close against a pressure instead of a vacuum for which they were designed, which caused the slow closing of the valves. Thus the leakage was comparatively high.

The accompanying curves obtained from the results of the tests show clearly the following facts concerning these pumps:

1. As the capacity curve is a straight line, the quantity of water pumped increases directly as the speed.

2. The horse power delivered varies directly as the speed as the discharge pressure was practically constant.

3. The duty also increases as the speed up to the point of maximum efficiency. It does not, however, vary directly as the speed.

4. The water rate decreases very rapidly at first as the speed increases up to about 2/3 the safe speed of the pump. Then it practically becomes constant. It will be noted that at very slow speed the water rate is extremely high. This is occasioned by the fact that at slow speeds, the pump stroke is shorter, thus causing a greater clearance which tends to increase the steam consumption. 80# of steam per h.p. hr. is considered a very good steam consumption for small pumps.

In order to compare the performance of both pumps, the duty and water rate curves of each have been plotted on the same sheet.

These show the Burnham to be the more efficient, and actual operation showed that it could be operated at twice the speed of the Deane without greater vibration or pounding. These are not only due to the difference in the ages of the pumps, but also to the evident superiority in construction of the Burnham.

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